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Sensorial and instrumental parameters of chocolate-flavored dairy desserts obtained in the retail trade

Parâmetros sensoriais e instrumentais de sobremesas lácteas sabor chocolate obtidas no mercado varejista

Camila Sampaio Cutrim[1*], Fernanda Romano Torres[1], Marco Antonio Sloboda Cortez[1]

[1]Universidade Federal Fluminense (UFF), Niterói, Rio de Janeiro, Brazil
[*]Corresponding author: camila.cutrim@yahoo.com.br

Abstract
The food industry has presented a great diversification of products with different flavors, textures, and target consumers. In particular, the dairy dessert branch presents a wide range of milk- and dairy-based products. Chocolate-flavored dairy desserts are one of the most common types of commercial desserts in Brazil. In this context, the aim of this work was to evaluate the sensory and instrumental attributes of chocolate dairy desserts available in the local market. Five brands of commercial dairy desserts available in retail markets were evaluated for their instrumental color, apparent viscosity and sensory attributes to determine how they affect consumers' perceptions using penalty analysis and hierarchical cluster analysis. A lack of uniformity between the analyzed samples was observed, a fact confirmed by the sensory perspective since for most of the attributes, consumers considered the samples to be above or below the ideal, and overall liking, color and flavor were the most significant attributes that could positively influence the buying decision. The attributes of sensory and instrumental analysis could be an important tool for the food industry to determine the points of weakness of products and the desires of target consumers.
Keywords: dairy product; color; viscosity; sensory evaluation

Resumo
A indústria alimentícia tem apresentado uma grande diversificação de produtos com diferentes sabores, consistências e públicos-alvo. Sobretudo o ramo das sobremesas lácteas apresenta uma vasta gama de produtos com base láctea ou de seus derivados. As sobremesas lácteas sabor chocolate são um dos tipos de sobremesas comerciais mais comuns no Brasil. Nesse contexto, o objetivo deste trabalho foi avaliar atributos sensoriais e instrumentais de sobremesas lácteas achocolatadas disponíveis no mercado local. Cinco marcas de sobremesas lácteas comerciais disponíveis nos mercados de varejo foram avaliadas quanto à cor instrumental, viscosidade aparente e atributos sensoriais para determinar como isso afeta a percepção dos consumidores, usando a Análise de Penalidades e a Análise Hierárquica de Agrupamento. Observou-se falta de uniformidade entre as amostras analisadas, fato que se confirma do ponto de vista sensorial já que entre as opiniões dos consumidores, para a maioria dos atributos, as amostras foram consideradas acima ou abaixo do ideal e que os parâmetros de impressão global, cor e sabor foram os atributos mais significativos que podem influenciar positivamente na decisão de compra. Podemos concluir que os atributos das análises sensorial e instrumental podem ser uma ferramenta importante para a indústria de alimentos para determinar os pontos fracos dos produtos e os desejos dos consumidores-alvo.
Palavras-chave: produto lácteo; cor; viscosidade; avaliação sensorial

1. Introduction

A broad range of ready-to-eat-milk-based desserts is available on the market, resulting in a wide variety of textures, flavors and appearances [(1)]. These dairy products involve the utilization of several ingredients, such as milk, cream, cocoa, sucrose, thickeners, chocolate aroma, and colorants. Variations in the quantity and characteristics of these ingredients and their combinations produce variations in the physicochemical and sensory properties of the final products, and these differences may influence their acceptance by consumers [(2)]. Knowing how consumers perceive a product's attributes and how these attributes influence acceptability and purchase intention can help the dairy food industry create and reformulate products to better meet consumer demand, ensuring a competitive advantage.

A parameter that presents great importance for food producers is objective color measurement since

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color affects product acceptability [3]. The application of colorimetry offers an objective method of color assessment because it is based on the whole visible spectrum and makes it possible to obtain the real chromatic profile of food products (4). Another important aspect of dairy dessert is the texture. Several studies have shown how this parameter can be influenced by the dessert composition [5,6,7,8]. Tárrega and Costell [2] studied the color, consistency and sensory measurements of commercial semisolid desserts and found that significant texture differences between samples were detected both by instrumental and sensory methods.

Consumer research is essential for the development and marketing of new products as well as for the reformulation of existing products [9]. The just-about-right (JAR) rating scale has been included in questionnaires of sensory consumer tests and marketing research for quite some time, often in conjunction with liking and sensory scales. It is an alternative method to acceptance tests that combines the assessment of attribute intensity and

hedonics by consumers to provide information on how consumers feel about a product and how much a sample deviates from an ideal point [10]. This analysis allows the use of penalty analysis (PA) on the data. PA is a statistical analysis method that is used by market researchers and product developers to gain an understanding of the product attributes that most affect liking by measuring changes in product liking due to the product having "too much" or "too little" of a specific attribute [11].

Acceptance test data can be used for hierarchical cluster analysis (HCA) to identify groups of consumers with similar preferences [12]. In this way, it is possible for producers to identify which consumer group consumes their product and other brands that compete in the same group. Chocolate is the most popular milk flavor and represents a popular option among children and adults [13]. The aim of this research was therefore to evaluate commercial samples of chocolate dairy desserts with regard to their instrumental color, apparent viscosity and sensory characteristics to determine how they affect consumers' perceptions using PA and HCA.

2. Material and methods

2.1 Samples

Five brands of chocolate-flavored dairy desserts covering the commercial range available in the city of Rio de Janeiro, Brazil, were purchased from local markets (Table 1). All samples were stored at 6 °C ± 1 °C until the test, when they were handed out to consumers. All analyses were performed within the shelf life of the samples.

Table 1. Ingredients of commercial chocolate dairy dessert as declared by the producers on the label.

Samples	I	II	III	IV	V
Dairy ingredients	Milk, cream, whey powder, skimmed milk powder	Milk, cream	Milk, milk powder	Milk, milk powder	Skimmed milk, cream, skimmed milk powder
Cocoa	Cocoa powder	Cocoa powder	Cocoa syrup and cocoa powder	Cocoa syrup and cocoa powder	Cocoa powder
Thickeners	Modified starch Carrageenan	Modified starch Gelatin Carrageenan	Modified starch Carrageenan Guar gum	Modified starch Carrageenan Guar gum	Modified starch Carrageenan Guar gum
Colorants	Natural caramel	Caramel IV	Natural caramel	Natural caramel	-
Acidity regulator	Disodium phosphate	Sodium hydroxide, Potassium hydroxide	Disodium phosphate	Disodium phosphate	Sodium phosphate
Flavoring	-	-	Artificial chocolate aroma	Artificial chocolate aroma	Artificial vanilla and hazelnut aroma
Stabilizer	Tetrasodium pyrophosphate	Sodium citrate	Tetrasodium pyrophosphate	Tetrasodium pyrophosphate	Sodium citrate

2.2 Instrumental analysis

The color parameters were determined by reflectance using a portable colorimeter Chroma meter (CR-400, Konica Minolta Sensing, Inc., Tokyo, Japan) using illuminant D65. All measurements were performed using a CIELab system, and samples were contained in optical glass cells 10 cm high and 6 cm diameter. The results were expressed in L* (lightness; 0 = black, 100 = white), a* (+a* = redness, −a* = greenness) and b* (+b* = yellowness, −b* = blueness) values. Chroma (C*) ($[a^{*2} + b^{*2}]^{1/2}$), hue (h*) (arctang b*/a*) and total color difference (ΔE*) ($[\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}]^{1/2}$) were calculated. To better guide the discussion, ΔE* was classified as very distinct (>3), distinct ($1.5 < \Delta E^* < 3$) and small difference (<1.5) [14].

The apparent viscosity of the desserts was determined according to the methodology described by Alvarado [15]. A rotational viscometer was used (Q860M21, Quimis ®, Sao Paulo, SP, Brazil) with rotor number 4 and 30 rpm. The samples were disposed in glass cups. The readings were held at 8 °C and expressed as millipascal seconds (mPA.s).

2.3 Sensory analysis

All tests were performed in a laboratory for the sensory analysis of food in climatized and well-lighted individual booths, and taste-free water and unsalted crackers were provided for palate cleansing. A total of 120 consumers of dairy products (84 women and 36 men)

aged between 18 and 68 years were randomly recruited. The samples were served sequentially in a monadic way using complete balanced blocks to avoid carry-over effects [16].

For the sensory analysis of milk desserts, the acceptance test was applied using a 9-point structured hedonic scale (9 = extremely liked to 1 = extremely disliked) with the following attributes: overall liking, color, aroma, flavor and consistency. The consumers were asked to indicate their purchase intention on a 5-point structured scale (1 = I certainly would buy to 5 = I certainly would not buy). The Just-About-Right (JAR) scale was used to evaluate the color, chocolate flavor, sweetness and consistency of the sample using a structured 9-point scale (9 = extremely more than ideal to 1 = extremely less than ideal).

This project was submitted to the ethics committee of Federal Fluminense University and approved by CEP/CONEP in 2018 with protocol CAAE: 95987318.4.0000.5243.

2.4 Statistical analysis

Instrumental analyses were performed in triplicate and analyzed by analysis of variance (ANOVA), and Tukey's test ($P< 0.05$) was used to compare the means. The Penalty Analysis (PA) combined JAR and overall liking tests to relate a decrease in consumer acceptance to attributes not at the JAR level [15]. JAR scores were evaluated through penalty analysis according to the methodology of Gaze et al. [12] and were considered significant when more than 20% of consumers evaluated the sample above or below the JAR level [17,18]. The scores of the acceptance test and purchase intention were analyzed through ANOVA and Tukey's test.

Hierarchical cluster analysis (HCA) was applied to the overall liking data to identify groups of consumers with similar preferences as in Cruz et al. [19], considering Euclidean distances (dissimilarly) and Wald's techniques (agglomeration method) and automatic truncation. The purchase intent data, computed in binomial form (buy > 3, not buy ≤ 3), were correlated with data from the acceptance test by logistic regression (LR) to find the affective characteristics that most influenced consumers' purchase intent of the product [20]. All statistical analyses were performed using the software XLSTAT version 2014.5.03 (Addinsoft, France) with a level of significance of 5%.

3. Results and discussion

The results obtained in the instrumental color and apparent viscosity analysis are shown in Table 2.

Table 2. Results of instrumental analysis of colorimetry and viscosity of chocolate milk desserts

Samples	Colorimetry					Viscosity
	L*	a*	b*	h*	C*	(mPA.s)
I	41.09^{b} ± 0.07	16.26^{a} ± 0.03	11.14^{b} ± 0.01	0.60^{b} ± 0.00	19.71^{b} ± 0.03	12,541^{c} ± 336.60
II	34.91^{e} ± 0.09	13.19^{e} ±0.01	6.41^{e} ± 0.02	0.45^{e} ± 0.00	14.66^{e} ± 0.01	15,952^{a} ± 168.19
III	39.69^{c} ± 0.04	13.53^{d} ± 0.01	8.46^{d} ± 0.02	0.56^{c} ± 0.00	15.95^{d} ±0.01	10,463^{d} ± 63.51
IV	54.68^{a} ± 0.08	16.13^{b} ± 0.04	11.61^{a} ± 0.03	0.62^{a} ±0.00	19.87^{a} ± 0.03	4,817,8^{e} ± 70.08
V	39.34^{d} ± 0.02	15.61^{c} ± 0.03	9.65^{c} ± 0.08	0.55^{d} ±0.00	18.35^{c} ± 0.06	13,654^{b} ± 97.21

*Means with different letters in the same column are significantly different (P<0.05) using Tukey's test.

Colorimetric analysis revealed that all parameters of all samples were significantly different (P>0,05). Regarding lightness (L*) and hue angle (h*), sample IV showed higher values (54.68 and 0.62, respectively), representing the sample with lighter coloration. In contrast, sample II obtained the lowest lightness (34.91) and h*(14.66) values and was characterized as the darkest sample. The positive values of parameter a * indicate a tendency toward red color tone [21], which agrees with the brown color that characterizes this kind of dessert. For the samples, the a* value was significantly different, varying from 13.19 to 16.26. These differences in color could be attributed to the formulations of each sample, considering variations in color, food type and quantity and cocoa type. There is a step in the cocoa extraction process called alkalization or the 'Dutch process' that aims to increase solubility, lower bitterness, and increase pH, resulting in a darker color of cocoa powder [22,23,24]. However, these are commercial samples, and the formulations are not fully known to support the correlation of cocoa type and product color.

By the total color difference (ΔE*), nearly all samples were considered very distinct: I x II (8.4); I x III (4.1); I x IV (13.6); I x V (2.4); II x III (5.2); II x IV (20.7); II x V (6.0); III x IV (15.5); III x V (2.4) and IV x V (15.5). There was greater relevance for the highest value of the difference between sample IV and the other samples.

In relation to the apparent viscosity, a significant difference between the samples was also observed: sample II was more viscous, and IV exhibited lower viscosity. All samples used carrageenan as a thickening agent, which interacts with milk proteins, particularly casein, and forms gels with smaller concentrations in

comparison with other thickening agents [7,25,26]. This difference in viscosity could be explained by the list of ingredients in each sample, as shown in Table 1; only sample II used gelatin as a thickening agent. Gelatin can improve the texture of dairy products, resulting in a firmer product with fewer tendencies toward syneresis. This effect has been associated with the interaction between gelatin and the casein matrix, which develops a stronger three-dimensional network [27,28,29].

Regarding the sensory analysis, the acceptance test and JAR results are shown in Table 3.

Table 3. Means results of acceptance and JAR of chocolate milk desserts

Item	Chocolate milk dessert samples				
	I	II	III	IV	V
Overall liking	7.72^{a} ± 1.21	7.84^{a} ± 1.17	6,66^{b} ± 1.96	5.13^{c} ± 2.26	7,67^{a} ± 1.33
Color	7.78^{a} ± 1.34	7.83^{a} ± 1.51	5.71^{a} ± 1.53	4.47^{b} ± 2,41	8.05^{a} ± 1.03
Aroma	7.25^{a} ± 1.37	7.18^{a} ± 1.53	6.69^{a} ± 1.85	5.90^{b} ± 1.87	6.78^{a} ± 1.53
Flavor	7.64^{a} ± 1.41	7.71^{a} ± 1.56	5.76^{b} ± 2.44	5.04^{c} ± 2.44	7.32^{a} ± 1.48
Consistency	7.44^{ab} ± 1.62	8.05^{a} ± 1.19	7.05^{b} ± 1.76	5.63^{c} ± 2.43	7.71^{a} ± 1.58
Color (%)					
Below JAR	38 (0.7)	3 (--)	23 (1.0)	93 (2.8)	18 (--)
JAR	56	54	53	7	68
Above JAR	6 (--)	43 (0.4)	25 (1.0)	1 (--)	14 (--)
Chocolate Flavor (%)					
Below JAR	43 (0.6)	28 (1.0)	47 (2.3)	83 (3.1)	45 (0.9)
JAR	52	61	26	14	49
Above JAR	6 (--)	11 (--)	28 (1.5)	3 (--)	6 (--)
Sweetness (%)					
Below JAR	18 (--)	23 (0.9)	27 (2.0)	36 (2.2)	11 (--)
JAR	63	61	35	33	51
Above JAR	19 (--)	17 (--)	38 (1.7)	32 (2.1)	38 (0.5)
Consistency (%)					
Below JAR	45 (0.9)	20 (0.5)	48 (1.0)	62 (1.5)	27 (0.2)
JAR	51	70	46	33	63
Above JAR	4 (--)	10 (--)	6 (--)	6 (--)	10 (--)

*Means with different letters in the same row are significantly different (P<0.05) using Tukey's test.

The Just-About-Right (JAR) scale is a 9-point scale where 1 to 4 = below JAR, 5 = JAR, and 6 to 9 = above JAR. The JAR results indicate the percentage of consumers that selected these options. The number in the parentheses represents the mean decrease in acceptance calculated when the percentage of citations exceeded 20%.

Samples I, II and V obtained the highest scores for overall liking, denoting the most accepted samples ($p<0.05$). In contrast, sample IV received the lowest mean and worst evaluation, but even so, it did not represent a rejection score. It is important to highlight that sample IV received the lowest scores in all attributes, which indicates that this formulation is not liked by the majority of consumers, mainly for color.

The JAR analysis results revealed that sample IV was strongly penalized due to its light color, revealing a mean decrease of 2.8. This finding corroborated the results of the color acceptance and instrumental color analysis, as previously shown. This sample was also penalized due to the chocolate flavor (mean decrease of 3.1); however, chocolate perception may also be influenced by light color. Thompson et al. [13] studied the preference mapping of chocolate milk and demonstrated a positive correlation between color intensity and chocolate flavor intensity.

Based on Villegas et al. [30], a specific attribute is present in optimal levels in a product when at least 70% of the answers are in the JAR group. The only sample that reached this percentage was sample II on consistency, which presented the highest value on the instrumental apparent viscosity analysis. These results demonstrate that there was no concordance in consumers' opinions since there was agreement for only one attribute. Considering this finding and the fact that none of the samples were rejected on overall liking, we conclude that there is a different consumer group for each sample.

HCA was applied to identify these consumer groups using the results of the acceptance of attributes: overall liking, color, aroma, flavor and consistency and the results of purchase intention. The results showed that the consumers were divided into 2 groups. Cluster 1 was composed of 79 consumers, 26 men and 53 women aged 19-68 years old. Cluster 2 was composed of 41

consumers, 10 men and 31 women aged 20-58 years old. Based on the 2 classes, a new evaluation was conducted by calculating the overall liking means for each sample in each group, as shown in Table 4.

Table 4. HCA results of chocolate milk desserts

Samples	Overall liking	
	Cluster 1	Cluster 2
I	7.96^{aA}	7.24^{aB}
II	8.33^{aA}	6.98^{aB}
III	7.84^{aA}	4.54^{bB}
IV	5.59^{bA}	4.24^{bB}
V	7.85^{aA}	7.39^{aA}

* Means with different small letters in the same column are significantly different (P<0.05) between samples using Tukey's test. * Means with different capital letters in the same row are significantly different (P<0.05) between classes using Student's t test.

According to Table 4, Cluster 2 was more rigorous, rejecting samples III and IV, while these same samples were accepted by Cluster 1. Comparing the samples between classes, it was verified that sample V was equally well accepted in both groups, which could suggest that this formulation might be used as a guide parameter for composition and sensorial scores since it satisfied all consumers. Nevertheless, these results should be analyzed critically because the tests were applied among consumers consisting mainly of students. Further study should be conducted for specific target consumers.

Ares et al. [31] studied the sensorial perception of chocolate milk desserts and used HCA to identify two groups of consumers that scored the overall liking of the samples differently. Consumers in Cluster 1 significantly ($P < 0.05$) increased their overall liking scores with decreasing sugar and cacao concentrations. On the other hand, consumers in Cluster 2 gave the highest overall acceptability scores to milk desserts with the highest cacao concentration, while the sugar concentration did not significantly ($P > 0.05$) affect their overall liking. This segmentation agrees with the study's results: no samples were considered ideal for chocolate flavor, and the HCA showed that all samples were accepted by at least one group.

The LR analysis (Table 5) demonstrated that overall liking, color, and flavor are the main attributes that can positively influence the buying decision. Of these three attributes, flavor is the most relevant; for every 1-unit increase in flavor acceptance, the purchase probability is enhanced by 3.44 times. One predictive value (74.10%) equivalent to a good ability to fit the experimental data was observed.

Table 5. Parameter estimates, probability, and odds ratio estimates for purchase intent of chocolate dairy dessert.

Source	Value	Pr > Chi²	Odds ratio
Overall liking	0,478	0,010	1,612
Color	0,223	0,041	1,250
Aroma	-0,033	0,762	0,967
Flavor	1,236	< 0,0001	3,441
Texture	0,058	0,644	1,059

De Morais et al. [32] evaluated probiotic chocolate dairy desserts and observed that the attributes of sweetness, milk chocolate flavor, sweet aroma, and mouth feel were critical to determine the acceptability of the products, whereas bitterness and bitter aftertaste were drivers of disliking.

Our results also showed that texture impacts liking. Other studies have shown that texture has an important influence on this kind of product liking. Ares et al. [33] analyzed vanilla milk desserts and noticed that the attributes of creaminess, stickiness, thickness, and mouth coating could be considered drivers of liking. On the other hand, the sample that had the highest milk flavor was considered a driver of disliking.

Bruzzone et al. [34] observed consumers' texture perception of milk desserts by trained and untrained panelists using intensity scales or a check-all-that-apply question. In general, texture liking was higher for the thicker and creamier samples, and the terms "thick," "nice texture", "creamy" and "very creamy" were positively correlated with them and were also positively correlated with texture liking. In contrast, the terms "liquid", "bad texture" and "not very creamy" were negatively correlated with texture liking, showing that consumers might dislike samples with these characteristics. These results are in agreement with previous research that highlighted the importance of creaminess as a driver of liking of the texture of milk desserts [35,36].

4. Conclusion

This study demonstrated a different varieties of commercial chocolate-flavored dairy desserts and revealed a lack of uniformity between them. This fact was confirmed by the sensory perspective; in the opinions of consumers, for the majority of the attributes, the samples were considered above or below the ideal. In addition, the need for effective optimization is highlighted because the consistency of only one of the samples was considered ideal for the attributes under study. It was observed that overall liking, color and flavor were the most significant attributes that could positively influence the buying decision. These results reveal the need for the industry to understand what consumers want so that products can fulfill their desires.

Conflicts of interest

The authors have no conflicts of interest to declare.

Author contributions

Conceptualization: M. Cortez and C. Cutrim. *Data curation*: C. Cutrim. *Formal Analysis*: C. Cutrim and F. Torres. *Project administration*: M. Cortez. *Methodology*: C. Cutrim and F. Torres. *Supervision*: M. Cortez. *Writing (original draft)*: C.

Cutrim. *Writing (review & editing)*: C. Cutrim, F. Torres and M. Cortez

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